

**UNITED STATES DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
OFFICE OF MOTOR CARRIERS**

Summary of Driver Fatigue Programs

September 1998

The Federal Highway Administration (FHWA) of the U.S. Department of Transportation regulates and supports the Nation's interstate commercial motor carrier industry.

The mission of the FHWA Office of Motor Carriers (OMC) is to help move people, goods, and commercial vehicles on our Nation's highways in the most efficient, economical, and crash-free manner possible. OMC is a leader in identifying and promoting new technologies which enhance motor carrier performance and safety. In order to accomplish our charge, OMC has placed a priority on human factors research, with a special attention given to driver fatigue and hours-of-service. Other areas of OMC human factors research include driver performance enhancement and driver medical qualifications.

education/outreach, and enforcement/consultation.

Driver fatigue is a safety issue of special concern to commercial motor vehicle transportation. CMV drivers may drive up to 10 hours continuously before taking a break, often drive at night, and sometimes have irregular and unpredictable work schedules. Much of their mileage is compiled during long trips on Interstate and other four-lane roadways. Because of their far greater mileage exposure and other factors, commercial drivers' risk of being involved in a fatigue-related crash is far greater than that of non-commercial drivers -- even though CMV drivers represent only about 4% of the drivers involved in known fatigue-related crashes and their rate of involvement per mile traveled is no greater than that of non-commercial drivers. In addition, other "competing" crash factors such as alcohol, speeding, and other unsafe driving acts are less common among commercial drivers and thus less important *relative* to fatigue.

The 1995 FHWA-sponsored National Truck and Bus Safety Summit and other industry conferences have identified driver fatigue as the top-priority commercial motor vehicle safety issue. The OMC supports this designation and has allocated its resources accordingly. Driver fatigue is a primary focus in four major OMC program areas: research and technology, rulemaking,

Research and Technology (R&T)

Driver drowsiness/fatigue is the dominant human factors research issue in the OMC R&T program. Altogether, OMC has more than 25 completed, ongoing, or planned R&T projects relating to driver drowsiness/fatigue and hours-of-service (HOS). These are described below.

Completed R&T

- **Driver Fatigue and Alertness Study (DFAS).** The DFAS, performed by the Essex Corporation, was the most comprehensive over-the-road study of commercial driver alertness ever conducted. It was a collaborative effort involving FHWA OMC, Transport Canada, the Trucking Research Institute (TRI) of the American Trucking Associations (ATA) Foundation, three motor carriers, and other research and industry organizations.

The study involved real revenue runs, 4 different driving schedules, 80 drivers, and more than 200,000 miles of highway driving. Numerous measures were taken of the drivers' physiology, alertness, and performance during driving and of their physiology during off-duty sleep periods. They included driving task performance (e.g., lane tracking), performance on microcomputer-based vigilance tests, continuous video monitoring of the drivers' face and the road ahead, and physiological measures (e.g., "brain waves") during both driving and sleep.

The DFAS results are major scientific inputs to the current re-examination of FHWA's 60-year-old driver HOS regulations. Major findings included:

- Driver alertness and performance were more consistently related to time-of-day than to time-on-task. Driver drowsiness episodes were eight times more likely between midnight and 6am than during other times.

- Drivers in the study did not get enough sleep compared to their "ideal" sleep needs. Drivers obtained an average of about 2 hours less sleep than their daily "ideal" requirements.
- Drivers' stated self-assessments of their levels of alertness do not correlate well with objective measures of performance. Drivers were not very good at assessing their own levels of alertness.
- There were significant individual differences among drivers in levels of alertness and performance.

The DFAS Executive Summary is available through the OMC home page (<http://mcregis.fhwa.dot.gov/study.htm>). The 60-page Technical Summary (PB 97-129688) and the 562-page project report (PB 98-102346) are available from the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA, 22161, 703-487-4828. (OMC Project Manager: Deborah Freund, 202-366-5541).

- **Fitness-for-Duty Testing.** This fatigue management technology involves the administration of psychomotor tests to drivers at the beginning of the job shift and/or during short breaks periodically during the shift. Through the TRI, Evaluation Systems, Inc. developed and evaluated a fitness-for-duty testing device for CMV drivers. Thirty drivers were tested on each of four cognitive/psychomotor tasks on the two different types of testing platforms, i.e. in-terminal desk top computers and truck cab mounted miniaturized computers. Data on the drivers' test results, acceptance of the tasks, the effects of terminal and cab environments on the computer hardware, and system reliability and maintainability all supported the feasibility of using short (5-10 minute) tests to identify fatigue drivers. This study documented the concept and feasibility of employing in-terminal and in-vehicle testing devices for accurately determining the fitness of CMV drivers to safely operate their vehicles. Results were reported in a 1994 FHWA publication #FHWA-MC-95-011. (OMC PM: Kate Hartman, 202-366-2742).
- **CMV Rest Areas: Making Space for Safety.** This TRI study determined what public rest area and

privately owned rest stop services are needed by CMV drivers and how well the current system meets these needs/demands. The study documented a significant shortage of rest area parking for commercial vehicles and drivers. It also revealed private sector efforts to expand spaces at truck stops to meet this need. Partly in response to the study, about half of U.S. States now permit their CMV weigh stations to remain open as rest areas when they are not being used as weigh stations. The U.S. Congress added in the 1995 National Highway System Designation Act a provision for 100% Federal funding of safety rest area construction and modification, a measure expected to stimulate expanded rest areas for trucks. The final study report (PB 97-124705) is available from NTIS. Proposed Highway Reauthorization legislation calls for a new study. A TEA21-directed follow-up study, as well as a conference work session on CMV parking "best practices" are under consideration. (Also see "Planned/Proposed R&T", below; OMC PM: Bob Davis, 202-366-2981).

- **Multi-Trailer Combination Vehicle Stress and Fatigue.** FHWA and the National Highway Traffic Safety Administration (NHTSA) co-sponsored this study, performed by Battelle, of the effect of multiple-trailer combination vehicle (MTCV) operation on driver stress and fatigue. Its goal was to determine whether there are differences in driver alertness and performance arising from driving single-trailer versus two different types of triple-trailer combinations: those employing A-dollies and those employing C-dollies. Twenty-four experienced MTCV drivers each drove six round trips (two with each configuration). Total mileage per driver was about 2,700 miles. Trailer configuration was found to affect driver stress/fatigue as measured by lanekeeping, driver subjective workload, and physiological state. Task demands were greatest with triple/A-dollies, followed by triple/C-dollies and, last, single-trailers. However, stress/fatigue differences relating to trailer configuration were small compared to the individual differences among drivers. Alertness correlated much more highly with driver individual differences than with vehicle configuration. A summary report on this study was submitted to Congress in March 1996. The final report will be

available in late 1998. (OMC PM: Deborah Freund, 202-366-5541).

- **Conference on Driver Vigilance Monitoring.** In December 1996, OMC and TRI jointly sponsored a conference focusing on technological approaches to counteracting fatigue, with emphasis on in-vehicle continuous monitoring of driver alertness/ performance and actigraphic monitoring of driver sleep/wakefulness. Topics addressed included basic research findings on driver alertness, updates on technology, and strategies for future deployment. Conference proceedings are available from Dr. Bill Rogers, TRI, (703) 838-7912. Similar future conferences are under consideration.
- **Conference on Managing Fatigue In Transportation.** This international, multi-modal conference, jointly sponsored by FHWA, ATA, NHTSA, the Association of American Railroads, the Federal Railroad Administration, and the National Transportation Safety Board (NTSB), addressed ways to improve transportation operator alertness and lower crash risk. Expert speakers addressed a variety of topics related to the improvement of operator fatigue management, including improving sleep, monitoring operator alertness, alternative approaches to HOS regulation, and new methods and technologies in fatigue management. Conference proceedings are available from Government Institutes, Inc.; 4 Research Place, Suite 200, Rockville, MD 20850, (301) 921-2355.
- **Assessment of Electronic On-Board Recorders for HOS Compliance.** This project, performed by the University of Michigan Transportation Research Institute (UMTRI) through a contract with the Private Fleet Management Institute (PFMI) of the National Private Truck Council (NPTC), assessed the costs and benefits of the use of electronic on-board recorders (EOBRs) for compliance with the HOS regulations. Average EOBR acquisition and installation costs averaged approximately \$2,000 per vehicle; annual operating and maintenance costs were about \$200 per vehicle. The use and benefits of EOBRs vary widely for different segments of the motor carrier industry; almost all current use is by private fleets. The benefits associated with electronic

HOS recording lie largely in the time savings for drivers in maintaining HOS logs. These savings averaged about 20 minutes per driver per day. Also, managers of fleets using EOBRs saved an additional 20 minutes per driver per month in management review and administration time. The final report from the EOBR assessment (is undergoing final review and will be available later this Fall. (OMC PM: Bryan Price, 202-366-5720).

- **Shipper Involvement in HOS Violations.** Congress directed the FHWA “to determine the scope, nature, and extent of shipper involvement in driver noncompliance with the safety regulations.” This study, conducted by Global Exchange, Inc., employed focus groups to generate qualitative data about shipper demands on motor carriers and drivers. The study found that pick-up and delivery demands by shippers do lead to HOS violations, but that *all* involved parties -- receivers, shippers, brokers, schedulers, dispatchers, and drivers themselves -- contribute to the problem of HOS noncompliance. Moreover, all of these parties have a role to play in resolving the problem. In particular, the fleet dispatcher plays a crucial role in setting schedules to balance HOS requirements and driver rest needs against delivery requirements. The final report from the shipper study has been published (FHWA-MC-98-049, December, 1997) and is available from NTIS. (OMC PM: Elaine Riccio, 202-366-2981).
- **Local/Short Haul Driver Fatigue Crash Data Analysis.** This small analytical study, performed by UMTRI, developed several definitions of local/short haul versus over-the-road trucks and examined the prevalence of driver fatigue as a principal factor in truck crashes. Data sources included the 1992 Truck Inventory and Use Survey and 1991-93 Trucks Involved in Fatal Accidents files. “Short-haul trucks” in these crash data files can be defined based on vehicle size (i.e., Class 3-6 single-unit straight trucks) and/or by operational nature (i.e., trip length). Not surprisingly, trip distance was found to have the most pronounced effect on the percentage of fatal crashes that were fatigue-related; shorter trips are associated with a much lower incidence. The risk of local/short haul truck involvement in fatigue-related fatal crashes is a fraction of that of over-the-road trucks. The project final report (FHWA-MC-98-016, NTIS

PB98-127129) is available upon request from FHWA and also through the National Technical Information Service (NTIS). (OMC PM: Ron Knipling, 202-366-2981).

- **Validation of Eye and Other Psychophysiological Monitors.** This OMC Intelligent Transportation Systems/Commercial Vehicle Operations (ITS/CVO)-funded effort was managed by the NHTSA Office of Crash Avoidance Research. Under the program, the University of Pennsylvania (UPENN) conducted laboratory experiments to evaluate the validity, sensitivity, and reliability of selected personal (psychophysiological) fatigue detection devices and measures, including eye closure measures such as PERCLOS, a measure of eyelid droop identified in earlier NHTSA research as being a promising index of fatigue. Other psychophysiological measures assessed included two eye blink measures, two electroencephalograph (EEG) measures, and a head movement detector. All measures had some validity, but the results corroborated most strongly the validity of PERCLOS. FHWA and NHTSA believe that PERCLOS is the most promising real-time measure of driver alertness for in-vehicle systems. For assured validity, in-vehicle alertness monitors should measure PERCLOS, PERCLOS correlates (psychophysiological or behavioral), or should otherwise be validated in a manner similar to this UPENN study. Publication of these findings is in process, and follow-up laboratory human factors studies of the driver-vehicle interface for PERCLOS-based in-vehicle alertness monitoring is currently being initiated. (PM: Paul Rau, NHTSA OCAR, 202-366-0418).
- **Effects of Loading and Unloading on Driver Fatigue.** Phase I of this study involved focus groups, a driver survey and interviews to understand the loading/unloading requirements across the industry. The amount of physical labor associated with long haul driving varies, depending upon type of cargo and other factors. For bus drivers, loading/unloading luggage was not a significant fatigue factor. For many trucking segments, drivers only supervise loading/unloading. Far more complaints were heard about fatigue from lengthy waiting periods associated with loading/unloading than from physical activity per se. Drivers who actually perform loading/unloading were concentrated in two commodity groups: household goods movers and

grocery haulers. These groups reported that they often become fatigued during and after the loading/unloading tasks. In some cases they claimed that this affects their driving alertness.

Phase II, recently completed, was a driving simulator-based study of the effects of the physical activity of loading/unloading on subsequent driver alertness. This experiment also measured and documented drivers' performance on a 14-hours-on (with 12 hours driving)/10-hours-off daily schedule and the "weekend" rest/recovery process over the 58-hour periods between two successive weeks of simulated driving. Results show that while loading/unloading has an invigorating effect early in the work day, the same activity later in the work day had a fatiguing effect on the drivers. The study also found that drivers performed well under the 14-10 daily regimen (e.g., there was no decrement in performance over successive days) and that there was full "weekend" recovery after one night of sleep. TRI and Star Mountain, Inc. are the study contractors. The draft final report for this project has just been received by OMC; it will be published late this year. (OMC PM: Bob Carroll, 202-366-9109).

- **Ocular Dynamics as Predictors of Driver Fatigue.** This driving simulator-based study addressed the question of whether directed eye movements (saccades) and other eye activities (e.g., eye blinks, eye closure) could be monitored as "leading indicators" of fatigue; i.e., measures obtainable before a driver reaches a dangerous level of fatigue. Recent advances in eye tracking made this technically feasible. Applied Science Laboratories and the Institute for Circadian Physiology, under subcontracts to TRI, also gathered data on napping as a fatigue countermeasure. Data collection has been completed and a draft report has been submitted; results support the concept of early ocular indicators of fatigue. Specifically, eyelid closure rates during blinks and PERCLOS (the percent of time eyelids are closed 80% or more) are significantly correlated with driver fatigue. In addition, afternoon napping was found to have a positive effect on alertness during subsequent evening and night driving. The final report for this project will be published late this year. (OMC PM: Bob Carroll, 202-366-9109).

- **Driver Work/Rest Cycles and Performance Modeling of HOS Alternatives.** In collaboration with FHWA, Walter Reed Army Institute of Research (WRAIR) is conducting this study. The objectives are to (1) gather data on representative wake-sleep cycles of CMV drivers operating in real work settings; (2) determine quantitative relationships among driving task performance and drivers' physiological and subjective responses; and (3) extend and validate a numerical model to predict performance based on prior wake-sleep cycles, sleep quality and quantity, and circadian state for a next-generation wrist-worn activity monitor or actigraph. The study will also provide information concerning potential use of actigraphs to improve the management of CMV driver fatigue.

Both field and laboratory data collections are complete. The field study involved 25 local and 25 long-distance drivers who wore actigraphs during their normal activities for up to 21 days. The laboratory data collection consisted of 15-day lab studies of 60 drivers using computer-based driving simulators, physiological and performance monitoring, and performance tests. The drivers were allowed 3, 5, 7, or 9 hours of sleep daily. Extensive data were collected on driving performance, physiological state, psychomotor and cognitive performance, and subjective self-assessments. The numerical model has undergone extensive first-round testing and assessment. Additional refinements will be made based upon the results of the laboratory study. Project findings are expected in early 1999. This project has provided unprecedented opportunities for cross-modal (FHWA, Federal Aviation Administration, Federal Railroad Administration) and cross-agency (DOT, Department of Defense, National Institutes of Health) coordination and resource sharing. (OMC PM: Deborah Freund, 202-366-5541).

- **Operational Test of Technological Aids to Improved Fatigue Management.** FHWA has just initiated, in response to Congressional direction, an operational test of fatigue-related technologies, in particular the actigraph, as an aid to effective CMV fleet safety management. Phase 1 of the program, being performed by

TRI, is assessing available technology and developing a detailed research design and plan. The project is expected to incorporate a study of individual differences in CMV driver susceptibility to fatigue and, potentially, employ alternative HOS schedules enabled by recent legislation granting FHWA additional waiver/exemption authority for operational tests. Industry and driver involvement and acceptance will be key to the success of this project. Transport Canada will also participate in this multi-year study. (OMC PM: Jerry Robin, 202-366-2985)

- **CMV Driver Sleep Apnea.** In response to Congressional direction, OMC is obtaining an estimate of the prevalence of sleep apnea in a population of truck drivers at high risk for the disorder, obtaining data on the daytime functional impairment and sleepiness of apneic drivers, and estimating the level of sleep apnea at which driving impairment becomes important. Study data may be used to raise industry awareness of the need for screening, diagnosis, and treatment of sleep apnea among drivers. The data may also form the basis for future research to identify remedial measures including new screening and detection technologies. The University of Pennsylvania Medical Center is performing this project through TRI. (OMC PM: Sandra Zywockarte, 202-366-2987).
- **Crash Investigation Project/Crash Causation Study.** OMC has contracted with UMTRI to compile a convenience sample of fatal truck crash investigations and reconstructions. UMTRI has developed a complete taxonomy of crash causes and contributing factors (including fatigue and other forms of driver inattention) and is applying it to investigation reports supplied by several States. Although the sample is not representative of all fatal crashes, important information about truck crash causes can be gleaned from these reports and appropriate modifications will be made to the coding forms. The results of this analysis will be published in early 1999.

In parallel, the Minnesota State Patrol, with grant funding from FHWA OMC, has designed a two-week truck crash investigation course. Plans are to incorporate a coding form developed by UMTRI into the Minnesota course and, later, into the FHWA

OMC National Training Center's training curriculum. Eventually, more and more police will be trained using this curriculum. As more police conduct uniform truck investigations and uniformly code the reports, these reports will be collected by FHWA OMC and a new crash causation database will be created. (OMC PM: Ralph Craft, 202-366-0324)

- **Scheduling Practices and their Influences on Driver Fatigue.** This two-year TRI study is surveying a representative sample of CMV drivers, carriers and shippers to determine operational scheduling requirements and recommended practices from the primary standpoint of fatigue management. Focus groups have been completed and surveys of drivers, dispatchers, motor carrier safety directors and chief executive officers have been drafted. A planned outcome of the work will be a symposium that will address scheduling practices for safer trucking operations. The project subcontractors are Western Highway Institute and Iowa State University. (OMC PM: Phil Roke, 202-366-5884).
- **Local/Short Haul Driver Fatigue Human Factors Study.** The Virginia Polytechnic Institute and State University Center for Transportation Research (VPISU CTR) is conducting this 3-year study to employ focus groups and direct observation to determine the role played by drowsiness/fatigue and inattention in driver errors and incidents in local/short haul (LSH) truck operations. The focus group phase of the study has been completed. The top five ranked LSH safety issues were: problems caused by drivers of private vehicles, stress due to time pressure, inattention, problems caused by roadway/dock design, and fatigue. Fatigue was identified as a critical safety issue by about one-third of the focus groups. When questioned specifically about fatigue, drivers identified 22 issues. The top five ranked fatigue-related issues were: not enough sleep, hard/physical workday, heat/no air conditioning, waiting to unload, and irregular meal times.

Phase 2 of this project is collecting direct, *in situ* observational data on driver fatigue and other driving safety issues affecting LSH operations. Two instrumented vehicles have begun collecting data. The instrumentation suites will include a capability for driver error/incident capturing and determination of antecedent conditions, including fatigue. Instrumented vehicle data on CMV driver backing and lane-changing performance will also be collected as an ancillary effort to this fatigue study. (OMC PM: Bob Carroll,

- **Sleeper Berths and Driver Fatigue.** This 3-year study, begun in May 1997, will determine the effects of sleeper berth use on driver alertness and driving performance. It will assess the quality of rest achieved while vehicles are stationary and in motion and evaluate the effects of irregular schedules and sleeper berth usage patterns on driver alertness and performance. VPISU CTR is conducting this work. The Task 1 report, providing results from various commercial driver focus groups, indicates that effective sleep in berths is sometimes constrained by the berth and truck design (e.g., berth suspension, ventilation, vibration while in motion, motor noise generated by adjacent vehicles or need to run engine to heat/cool berth area), requirements at cargo pick-up and delivery points, the team driver's operating skills and courtesy while the other driver rests, and drivers' perception of the safety and privacy of available parking en route. The quality of sleep obtainable in moving vehicles is a particular issue of concern. Development of the research plan to gather empirical data, using instrumented vehicles and standard sleep monitoring methodologies, is in progress. (OMC PM: Bob Davis, 202-366-2981).
- **CMV Crash Rate by Time-of-Day.** This small analytic study, performed by UMTRI in support of the current HOS rulemaking, is accessing available crash data files and information on CMV mileage exposure to determine the CMV crash involvement rate (per mile traveled) by time-of-day. This issue is relevant to current OMC deliberations on CMV HOS and may also provide useful information to help carriers schedule truck trips to minimize crash risk. Since there is no national record of CMV mileage exposure by time-of-day, the study will focus on smaller crash samples such as those of individual states and/or major turnpikes for which both crash and exposure data can be disaggregated by time-of-day to determine corresponding crash rates. This study will be completed in early 1999. (OMC PM: Ron Knipling, 202-366-2981).
- **Truck Stop Fitness Facility Study.** Major obstacles to better fitness and health for over-the-road drivers are the sedentary nature of the job and the lack of readily available fitness facilities. Exercise has been shown to combat fatigue, reduce stress, improve alertness, and enhance sleep. This 1-year TRI study is assessing the level and patterns of use of truck stop fitness facilities by 500 volunteer truck drivers that regularly operate along the I-40 corridor. The study will also address other issues including the benefits perceived by drivers, whether they are making other lifestyle changes, and economic viability of truck stop fitness facilities. A private enterprise, Rolling Strong Gyms, is providing the fitness facilities. The first three gyms have opened in North Little Rock, AR (Pilot Truck Stop), Oklahoma City, OK (Pilot Truck Stop), and Knoxville, TN (Petro Truck Stop). Each Rolling Strong Gym is fully equipped with aerobic and weight resistance equipment and showers, and is staffed full-time by a certified fitness expert. This government-industry partnership has received widespread positive press and media exposure including stories by Extra!, the Public Broadcasting Corp., and ABC's Good Morning America. It is an innovative, holistic approach for improving highway safety. (OMC PM: Jerry Robin, 202-366-2985).
- **Driver Compensation Practices and Safety.** This new study will seek to determine whether and how driver pay levels and methods (e.g., by the hour, by the mile) influence CMV safety as measured by such indices as crash rate and citation (e.g., HOS violations). Science Applications International Corporation (SAIC) is the prime contractor, and the University of Michigan's Trucking Industry Program (UMTIP) is the subcontractor. Phase 1, currently near completion, consists of a literature review and feasibility study. UMTIP will examine the possibility of using some of its ongoing work (not funded by FHWA) to explore in detail the relationship between pay and safety, and explain what specific methods and tests might lead to reliable results. One possible project which may address this issue is a planned truck stop survey, during which UMTIP will conduct detailed interviews with approximately 1,000 drivers at truck stops in the Midwest and West. The survey will begin in the early fall of 1998 and continue for almost 16 months. UMTIP will also be conducting audits of various Less-Than-Truckload (LTL) carriers, which will include gathering extensive pay and safety data. These non-FHWA-funded information sources may be used for future FHWA-funded analyses

of the pay compensation issue. (OMC PM: Chuck Rombro, Analysis Division, 202-366-5615).

- **Driver-Vehicle Interface for In-Vehicle Alertness Monitoring.** This Intelligent Vehicle Initiative (IVI)-funded effort is being managed by the NHTSA Office of Crash Avoidance Research and is a follow-up to the PERCLOS validation study described earlier. Under the program, the University of Pennsylvania will conduct laboratory experiments to evaluate the effectiveness of various potential elements of the driver-vehicle interface (DVI) of in-vehicle CMV driver alertness monitoring devices. Under this project, Carnegie Mellon Research Institute has developed a new camera and related software that can monitor and analyze a driver's PERCLOS in real-time. Other DVI components to be assessed include real-time gauges, informational alarms/warnings, and alerting stimuli. The study will make recommendations regarding optimal DVI design elements for CMV driver alertness monitors. This new study will be completed in the Spring of 1999. (PM: Paul Rau, NHTSA OCAR, 202-366-0418).

Planned/Proposed R&T

- **Intelligent Vehicle Initiative Driver Monitoring Research.** Driver monitoring is a key component in the new ITS Intelligent Vehicle Initiative (IVI). Plans are underway for an operational test of continuous driver monitoring systems as well as other vehicle-based technologies beginning in FY'99. The heavy truck portion of the IVI will be managed by the OMC ITS/CVO division in collaboration with other DOT modal administrations. The planned operational test will foster the ability of both system suppliers and truck users to commercially deploy effective on-board technologies. Information on the IVI may be obtained from the OMC Project Manager, Kate Hartman, at 202-366-2742, the DOT ITS web page (www.its.dot.gov) or the ITS America web page (www.itsa.org).
- **PERCLOS Technical Conference.** With funding provided by the IVI program, a technical conference/ workshop is planned for the Spring of 1999 to discuss recent scientific validation findings regarding PERCLOS and other eye activity measures as metrics of alertness, and the status of efforts to develop in-vehicle sensors to continuously measure PERCLOS as an "alertometer." The conference will also

address the potential and appropriate uses of "alertometer" data and ways to ensure the active participation and acceptance of drivers and management in the use of such technologies. Since PERCLOS will likely be a key metric employed in any operational test of alertness monitoring technology, the workshop will also provide an update of FHWA's plans for implementing the IVI operational tests, as described above. (OMC PM: Bob Carroll, 202-366-9109)

- **Rest Area Conference/Working Session.** As a follow-on to the 1996 Rest Area study and adjunct to the December 1998 National Safety Summit, FHWA will conduct an expert panel workshop to address CMV rest area availability and safety needs. This session will identify, consider, and promote "best practices" developed by public and private sector organizations and jurisdictions to expand the number of available parking spaces for CMV drivers needing rest along the Nation's highways. This conference will also provide the FHWA with information it can use to satisfy the TEA21 requirement for a second national review of truck parking needs. (OMC PM: Bob Davis, 202-366-2997)
- **Crash Investigation Project/Crash Causation Study.** Plans for a longer-term crash causation project are also underway. Since the NHTSA already has crash investigation teams in 24 locations across the country as part of the National Automotive Sampling System (NASS) program, the FHWA OMC is considering using these teams to conduct a special study of large truck crashes. A feasibility study will assess and plan a program of moderately in-depth investigations of large truck crashes that result in fatality or serious injury. Given the diversity of the 24 locations, a quasi-representative national sample of large truck crashes would be obtainable. OMC believes that in-depth investigations are necessary to determine the causes of crashes, including fatigue. (OMC PM: Ralph Craft, 202-366-0324)

Additional R&T under consideration include an assessment of the HOS and fatigue management requirements of motor coach drivers, a study of driver performance management practices related to fatigue and other in-vehicle technologies, and

development of a national data system for human factors research.

Rulemaking

OMC applies its research results to the development of cost-effective and safety-promoting CMV regulations. An Advance Notice of Proposed Rulemaking (ANPRM) on CMV HOS was issued in late 1996 (61 Federal Register 57252); the comment period closed in mid-1997. This HOS rulemaking will likely result in the first major changes to the CMV HOS in nearly 60 years. The rulemaking addresses the potential for both conventional HOS rules and performance-based alternatives, with the latter including both fleet management and individual monitoring approaches to performance-based regulation. An advantage of performance-based approaches is the potential for synergy between these approaches and driver awareness of their alertness changes. The introduction of valid fleet safety and/or individual driving performance measures and the provision of this information as feedback to drivers will likely increase awareness of their alertness and of sleep hygiene practices which affect alertness and performance. Of course, the effectiveness of alertness monitors or other performance-based approaches must be demonstrated before their use is permitted as an alternative to prescriptive HOS.

Although OMC has set its long-term sights on performance-based rules, the current focus is on prescriptive HOS rules. Critical HOS-related issues include:

- Maximum driving time (currently 10 hours).
- Minimum off-duty time (currently 8 hours).
- Work cycle implications of the above (current rules encourage an 18-hour cycle for maximum productivity in long-haul operations).
- Distinctions between driving and non-driving duty time; currently, the maximum continuous on-duty time is 15 hours, of which 10 hours may be driving.
- Day/night differentials to encourage day driving (currently there are none).
- Maximum cumulative on-duty hours (currently, 60 hours in 7 days or 70 hours in 8 days).

- Providing flexibility for different CMV operations and situations, while at the same time ensuring adequate daily and weekly rest for all CMV drivers.
- Special provisions; e.g., current sleeper berth provision allowing splitting of off-duty hours.

These and other issues are being addressed within the Department. When considering other regulatory initiatives, the agency seeks to achieve “win-win-win” outcomes for public safety, CMV productivity, and driver quality-of-life. The FHWA firmly believes that the current HOS rules can be improved in all three respects.

For information on the HOS rulemaking initiatives, contact David R. Miller, (202) 366-1790, FAX (202) 366-8842. Internet users may access the HOS ANPRM at the Federal Register web page at:
www.gpo.gov/su_docs/aces/aaces002.html

Education/Outreach

Together with the ATA, NPTC, and other industry partners, the OMC has undertaken an active fatigue education/outreach effort. This outreach program uses a multimedia approach to inform a wide range of audiences -- the general public, motor carriers, professional truck driver associations, and truckers themselves -- about the hazards of driving while fatigued. A major goal is to educate all 7 million commercial driver's license holders on how to recognize fatigue and about the importance of adequate rest and healthy work and lifestyle choices.

OMC's Fatigue Outreach project has provided funding to the TRI for several major information/education initiatives. This has included the development and distribution of “Awake at the Wheel” public service announcements to radio stations nationwide. In addition, more than 1,000,000 “Awake at the Wheel” print brochures have been printed and are being distributed to truck drivers, carriers, and other organizations involved in motor carrier safety. Under the same program, TRI has produced a video to educate truckers and their families about fatigue and the importance of adequate sleep. A train-the-trainer instructional program has also been developed and is being conducted for fleet safety managers and truck driver training personnel. Fatigue education materials may be obtained by calling 1-800-ATA-LINE directly. The OMC Fatigue Outreach manager is Dave Longo, 202-366-0456.

In addition to educating drivers on fatigue and safety,

we want them to understand and appreciate how sleep, diet, exercise, and lifestyle contribute to a personal state of “wellness” and enhanced work performance. Through the TRI and the PFMI, FHWA is funding the development of a fleet-based driver wellness program. The initial phase identified critical issues and concerns relevant to driver wellness, including ways to change personal attitudes and self-perceptions of wellness. A survey of 448 experienced, mostly long-haul drivers indicated the following priority health/wellness concerns: lack of family time, lack of exercise, weight, fatigue, poor diet, and stress. The project is employing an attitude/behavior change model which conceptualizes four stages in the path toward positive change: precontemplation/denial, contemplation, preparation/action, and maintenance. Several model wellness programs will be developed for integration into company operations. Health and wellness information will also be disseminated for use by drivers and their families. The OMC PM is Albert Alvarez, 202-366-4706.

FHWA is also encouraging the installation of exercise facilities for drivers at private truck stops near Interstate highways. A new program, described in more detail earlier under R&T, is assessing the level of use of these facilities and, indirectly, their economic viability as a truck stop amenity to attract drivers.

On December 6-10, 1998, OMC will conduct the Second Truck and Bus Safety Summit in Atlanta. It will present a National Agenda for Motor Carrier Safety developed as a follow-up to Summit I. A number of goals and recommendations contained in the national agenda are fatigue-related. This includes goals to improve CMV driver HOS rules; better define the responsibilities of shippers, receivers, and other parties in relation to motor carrier safety; improve CMV driver working conditions and occupational health; utilizing rumble strips to reduce run-off-road crashes; and improving rest areas along high-use CMV corridors.

Finally, OMC has worked cooperatively with the ATA to provide low-cost training to managers of small and new interstate fleets on how to comply with the Federal Motor Carrier Safety Regulations (FMCSRs). This includes compliance with regulations on driver qualifications and HOS/log book compliance. In 1997, 35 one-day seminars on FMCSR compliance were conducted at locations across the country. For information on these programs, contact Jai Kundu, ATA, 703-838-1852.

Enforcement/Consultation

OMC, with its state partners, uses a variety of enforcement tools to ensure motor carrier and driver compliance with HOS and log book requirements as prescribed in the FMCSRs. Each year, more than 14,000 HOS and log book violations are cited during compliance reviews of motor carrier operations. Carriers in compliance, but still experiencing a high crash rate, are provided with consultation regarding specific crash countermeasures and management approaches for minimizing driver fatigue.

Roadside driver/vehicle inspections performed under the Motor Carrier Safety Assistance Program annually result in more than 130,000 drivers being placed out of service for HOS or log book violations. This is about 80% of all driver out-of-service violations and represents about 6% of all drivers inspected annually.

More severe enforcement actions are taken against carriers or drivers with repeated or egregious violations. Usually, such cases result in fines or other civil penalties, but criminal sanctions are applied to extreme violators. In one case, federal criminal charges were brought, and a conviction obtained, against a carrier that forced drivers to falsify logs and violate HOS rules. In another case, a \$60-million-a-year aluminum/steel hauler was ordered by FHWA to cease interstate operations because of chronic HOS and log book violations.

An anticipated future trend, consistent with OMC's fatigue education/outreach and FMCSR compliance programs, is a greater emphasis on the consultative role of OMC Safety Inspectors in helping to prevent and correct driver fatigue and HOS-related problems before enforcement actions against carriers are necessary.

NHTSA Driver Fatigue Programs

The National Highway Traffic Safety Administration (NHTSA) of the U.S. DOT has two major program areas relating to driver fatigue. In the area of Traffic Safety Programs, NHTSA is responding to a U.S. Congressional directive to develop and evaluate a drowsy driving public information and education program. In its R&D program, NHTSA is developing and testing a prototype drowsy driver detection system and related ITS countermeasures, as well as performing statistical analyses of the drowsy driver crash problem.

Public Information and Education

NHTSA's drowsy driving public information and education (PI&E) program is directed toward high-risk groups within the non-commercial driving population. A basic research element of this work is analyzing the role of drowsiness and inattention in driving among "at risk" individuals such as shift workers, military personnel on weekend leave, and college students on breaks. The NHTSA Vehicle Research and Test Center instrumented the personal vehicles of 8 volunteers from these "at risk" categories. Inconspicuous and unobtrusive video cameras captured drivers' faces and the roadway scene. Other sensors collected data on steering, lane keeping, and travel speed. Facial videos were used to assess alertness using the eye measure PERCLOS. In addition, the study is analyzing instances of driver inattention to the driving task, as evidenced by eye glances away from the road or distracting in-vehicle activities, to determine their relation to alertness and their role in driving errors. Results from this naturalistic, real-world study will be available this Fall.

The NHTSA PI&E program is being performed in cooperation with the National Center on Sleep Disorders Research of NIH. Other elements of the program include:

- Investigating the incidence and nature of fatigue in motor vehicle operation.
- Planning, developing, testing, and evaluating a PI&E program. A pilot program for shiftworkers is planned.
- Implementing the validated PI&E program on a broader scale.

A new report entitled *Drowsy Driving and Automobile Crashes* (DOT HS 808 707, April, 1998) has been published as part of the NHTSA driver fatigue PI&E program. For further information, contact Dr. Jesse Blatt of the NHTSA Office of Research & Traffic Records (202-366-5588).

Crash Avoidance Research & Development

NHTSA's R&D program on drowsy/fatigued drivers focuses on the development of a vehicle-based drowsy driver detection and warning system. NHTSA is supporting R&D on detection algorithm refinement, sensor development, and the driver interface; i.e., advisory messages and alerting stimuli. The project has field-tested a prototype system for use in trucks. Over-the-road data have

been collected on system performance and useability; these data are currently under analysis and will be published during 1998. Additional current work is further refining and validating algorithms and developing a video-based eyelid droop sensor. Promising new R&D has demonstrated that a low-cost continuous driver eye monitoring sensor is technologically feasible.

NHTSA R&D also sponsored a Small Business Innovation Research (SBIR) grant to demonstrate the feasibility of an unobtrusive driver eyelid droop and eye point-of-regard monitor that can be used reliably in real-time under driving conditions. In Phase 1 of this SBIR project, LC Technologies wrote image processing software and demonstrated a laboratory system that identifies the pupil, iris, and eyelids within the camera range; computes the size of the eyelid opening; determines the percentage of the pupil occluded by the eyelid opening; and locates the direction of the eye's gaze. Future goals for this research are to adapt this equipment for use in a truck on the road.

The convergence of ongoing ITS R&D related to other classes of crashes will also have the potential to reduce drowsy driver crashes. ITS projects include programs on single vehicle roadway departure crashes and rear-end crashes, and the ITS concept of Automatic Collision Notification intended to speed emergency medical response to crashes.

NHTSA's research program seeks to better assess the driver fatigue problem. Analyses of NHTSA crash databases have improved our understanding of crash characteristics and, in particular, have led to better estimates of crash problem size. Ultimately, however, direct observation of drivers using in-vehicle monitoring devices will provide the most valid data on driver drowsiness. NHTSA has developed, and is deploying, a sophisticated, unobtrusive instrumentation suite in test vehicles to obtain "real world" data on safety-related driver performance, behavior, and alertness.

Further information on the NHTSA program may be obtained from Dr. Paul Rau of the NHTSA Office of Crash Avoidance Research (202-366-0418).

Conclusion

CMV driver fatigue is a complex issue and can be viewed in several different ways. The commercial driver, like any transportation operator, is performing a complex sensory-motor task in a vehicle. A classic problem for human factors research is to understand operator errors and devise operational or design changes to prevent them. Physiological and behavioral studies have revealed ways that driver alertness and performance deteriorate due to fatigue, and how intelligent devices may potentially act to detect and prevent this deterioration. Driver off-duty lifestyle and sleep habits play a key role in determining alertness and performance while on-duty driving. At the level of the physical transportation environment -- such as the highway -- design changes such as rumble strips may prevent crashes due to operator fatigue. CMV drivers also perform their work against the backdrop of an operational environment including government HOS regulations, penalties for violations, and company management practices including selection, training, scheduling, and incentives for safe performance. To the greatest extent possible, the operational environment must support alert driving. Fleet management practices, in particular scheduling and policies regarding the taking of rest breaks while on duty, can greatly influence driver lifestyle and the priority they place on sleep. At the broadest conceptual level, there is the cultural environment of public information and attitudes about the role of sleep and alertness in safety. The benefits of sleep must be valued by society just as we value the benefits of exercise and a healthy diet. FHWA OMC's driver fatigue programs reflect this multi-level conception of driver fatigue and ways that drivers, fleet managers, other industry parties, government, and society can work together to improve fatigue management.

Further Information

Internet users may access this information through the OMC homepage **<http://mcregis.fhwa.dot.gov/fatigue.htm>** For further information on the driver fatigue R&T programs of the FHWA/ OMC, please contact Ronald R. Knipling, Ph.D., Chief, Research Division (HCS30), Office of Motor Carrier Research and Standards, FHWA, U.S. DOT, 400 Seventh Street, SW., Washington, DC 20590; Phone (202) 366-2981; FAX (202) 366-8842; e-mail **ron.knipling@fhwa.dot.gov**. The FHWA OMC is also interested in receiving copies of new research relating to driver fatigue. Please send such reports to the address above, or fax/e-mail them to OMC, attn: Ron Knipling.

FHWA OMC maintains a web site providing information on the full range of its regulatory and other

activities to promote truck and bus safety. The address is: **www.fhwa.dot.gov/omc/omchome.html**.

DOT-wide activities related to transportation operator fatigue are described in the DOT's Fatigue Resource Directory at **www.hf.faa.gov/dot/fatigue/**. The directory contains a wealth of information on government and non-government fatigue-related R&T and educational programs.

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September 10, 1998